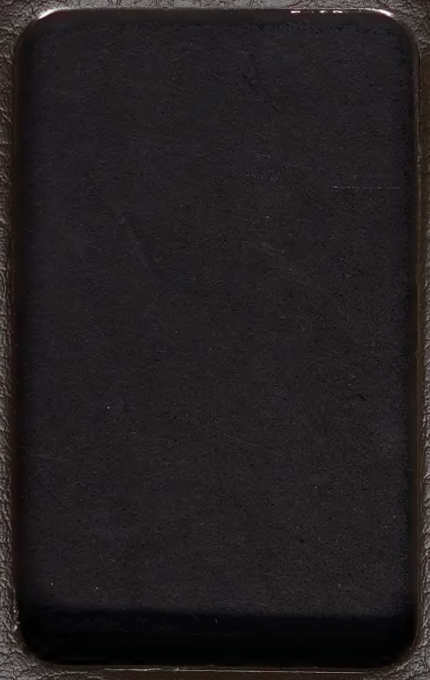
105/CA 2600

DIGITAL MULTIMETER 4440

MP MASTER
MA24229

Schlumberger

TECHNICAL DATA



105/CA 2600

DIGITAL MULTIMETER 4440

Part No: 510660031	Date of Issue: Sept. 1972

THE SOLARTRON ELECTRONIC GROUP LTD.
Farnborough · Hampshire · England · Telephone 44433
Cables: Solartron Farnborough, Hants · Telex: 85245 Solartron Fnbro

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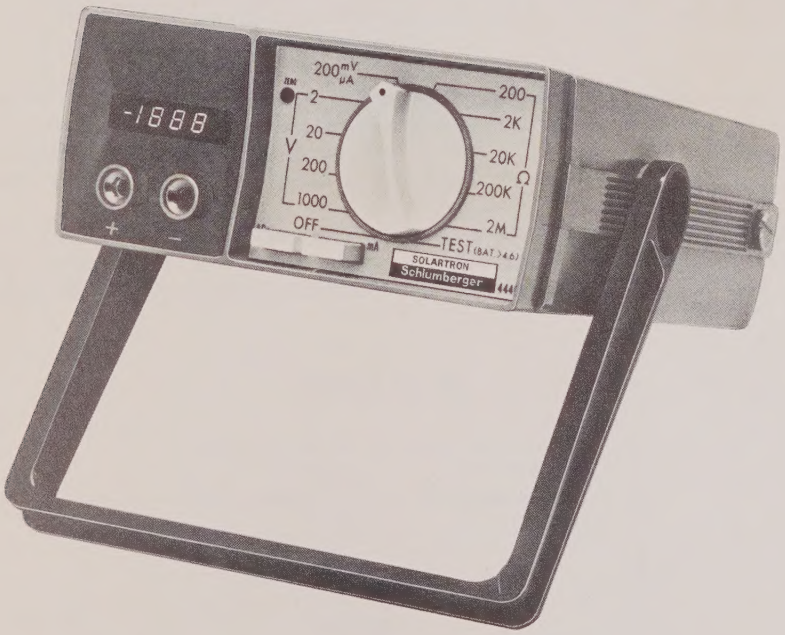
DIGITAL MULTIMETER

MODEL 4440



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SECTION 1 General

INTRODUCTION

This section presents the design and operating principles of the Solartron 4440 Digital Multimeter. Complete circuit diagrams and assembly drawings are included for reference in Section 2.

The 4440 incorporates all circuitry needed to make measurements of dc voltage and current, ac voltage and current, and resistance. The basic measuring circuit is a high impedance bipolar analogue to digital (A to D) converter operating on the dual-slope principle. All inputs other than dc volts are converted to dc volts for measurement by this circuit.

Resistance is measured by passing a scaled constant current through the unknown and measuring the dc voltage across it. Alternating voltages are converted to dc by a mean sensing, rms calibrated converter assembly, with a full scale output voltage of 200mV dc for all ranges. Current is measured by the voltage drop across a shunt. The full scale voltage across the shunt is 200mV.

The DC voltmeter and the several conversion circuits are interconnected by two push button switches and a rotary range switch which make possible decimal point switching, input ranging, gain changes in the A to D converter, and shared usage of the precision input attenuator.

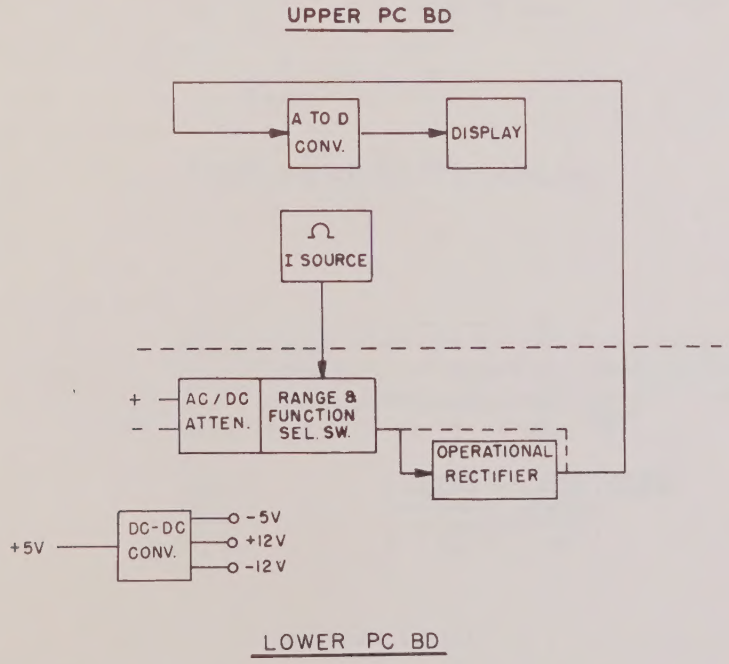


Fig. 1.1 Circuit Partitioning

DETAILED CIRCUIT DESCRIPTION

DC VOLTMETER CIRCUIT

The A to D converter is common to all measuring functions. The input voltage may be either 200mV dc or 2V dc depending on range setting. All the voltages are scaled to one of these ranges by suitable attenuators, shunts, or converters. The display has a maximum reading of 1999 accompanied by decimal points, polarity sign and an overrange indication.

The circuit operation will be explained with the aid of Waveforms Figure 1.2 and the Block Diagram Figure 1.3.

Dual Slope A to D Conversion

Dual slope conversion is an integrating method which has the following inherent advantages:

1. By proper choice of oscillator frequency, the effect of power frequency interference is reduced.

2. Internal clock frequency accuracy is unimportant since the input voltage is converted into a ratio of two time intervals.

3. Comparator threshold accuracy is unimportant.

The technique employed in the Model 4440 has the added advantage of not switching the input signal, eliminating a source of noise which can disturb the quantity being measured.

Figure 1.2 shows the waveforms associated with one conversion cycle. The equation relating Ein to a time ratio is as follows:

$$\frac{E\,in\,T_1}{RC} = I_{REF} - Ein/R\ \frac{T_2}{C}$$

$$\text{since } T_1 + T_2 = T$$

$$T_2 = Ein\ \frac{T}{I_{REF}\,R}$$

$$Ein = \frac{T_2}{T_1 + T_2}\ I_{REF}\,R$$

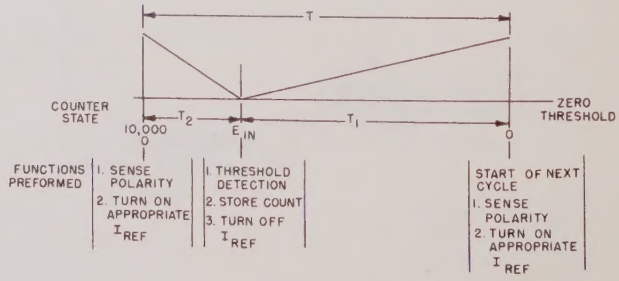


Fig. 1.2 Waveforms

Basic Logic

The A to D converter logic is incorporated on a MOS-LSI circuit. This includes the portion of the block diagram enclosed in dotted lines. The conversion period is fixed at 10 000 clock pulses. With a count advance from 9999 to 0000, the polarity of the integrator output is sensed and stored. Additionally, one of two current references is turned on based on the polarity data. When a comparator threshold is reached, the current reference is turned off, and prior to a new counter advance, the counter states are stored in a register. Meanwhile the counter continues counting.

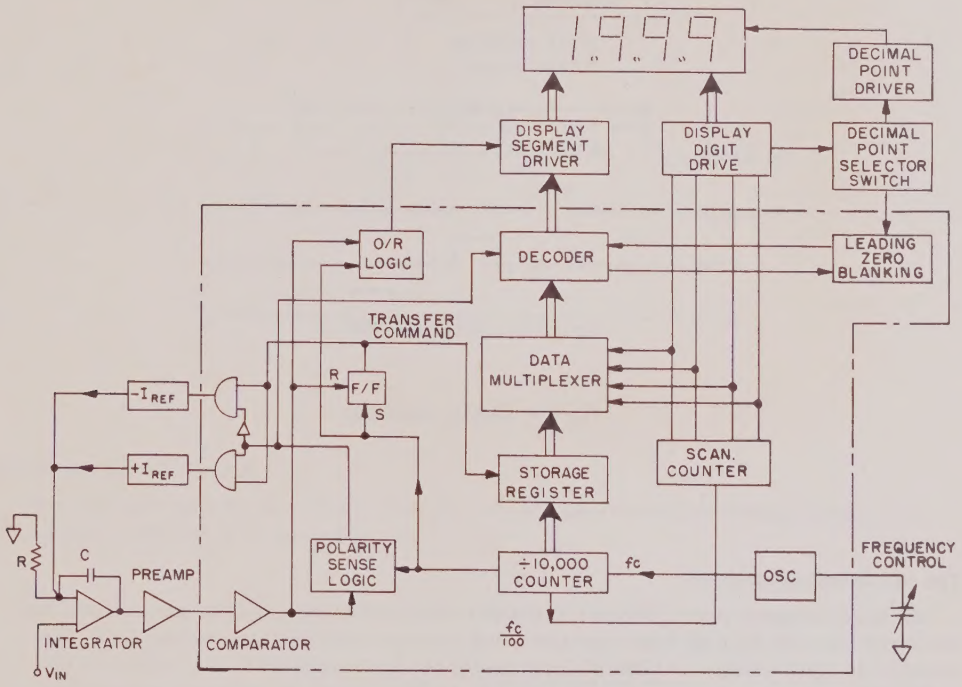


Fig. 1.3 A to D Converter Block Diagram

Strobed Display Operation

The display digits are sequentially energized with each digit updated approximately 100 times per second. The digit-select logic output and the seven segment logic outputs are synchronously supplied by the LSI circuit. (See Figure 1.4). Segments are energized on a 10% duty cycle basis to enhance the LED display efficiency.

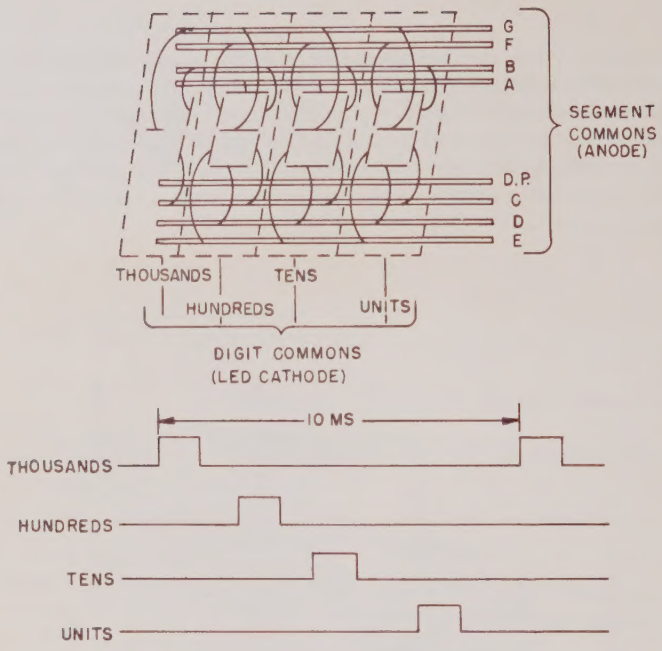


Fig. 1.4 Display Strobing

The Non-Inverting Integrator

The basic integrator circuit, Figure 1.5, consists of an operational amplifier connected in the non-inverting mode for high input impedance, and the logic-controlled current source. If, for example, an input voltage of +100mV is applied, the feedback amplifier causes point A to rise to 100mV producing a current through resistor R. In the absence of a reference current, this constant current charges capacitor C and point B will rise linearly to support this charge rate.

When, at the count of 10 000, a reference current is switched into point A, the reference source will supply the current through R and the remaining current will discharge capacitor C. Point B will then fall back towards zero taking 1000 clock bits to do this, giving a display of 100.0. Since one complete period is 10 000 counts, the rise will take 9000 clock bits and the fall will take 1000 clock bits. Other input voltages will give rise to corresponding fall times and displays.

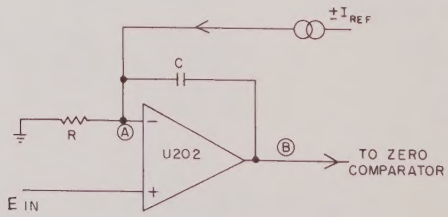


Fig. 1.5 Integrator Circuit

Offset Adjustment

To compensate for offset voltages in U202, which would produce a continuous ramp at B with zero input, the ground of the integrating resistor R is returned to an adjustable voltage, low impedance source as shown in Figure 1.6.

Resistor R231 and its associated resistors provide a 50Ω source, adjustable to ± 8mV to accommodate an 8mV possible offset voltage in the amplifier. The offset adjustment need not be changed when changing ranges.

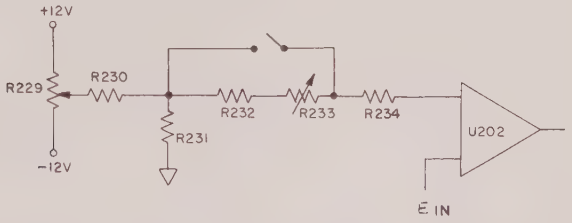


Fig. 1.6 Offset Adjustment

Reference Current Circuits

The reference current generators consist of a common-base transistor constant current source. The positive reference is shown in Figure 1.7.

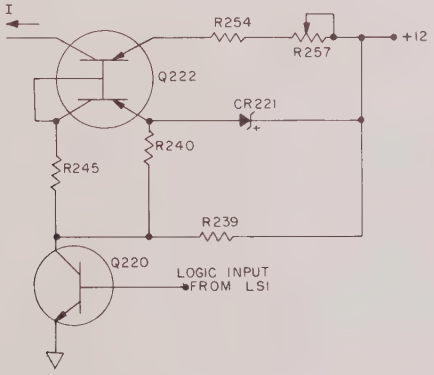


Fig. 1.7 Reference Current Circuit

INPUT ATTENUATION

On the 200mV, 2V and 200μA ranges, Ein is applied without attenuation as shown in Figure 1.8. A common attenuator is used for both ac and dc measurements on the other voltage ranges as shown in Figure 1.9.

A 2 pole RC network gives rejection of series mode interference.

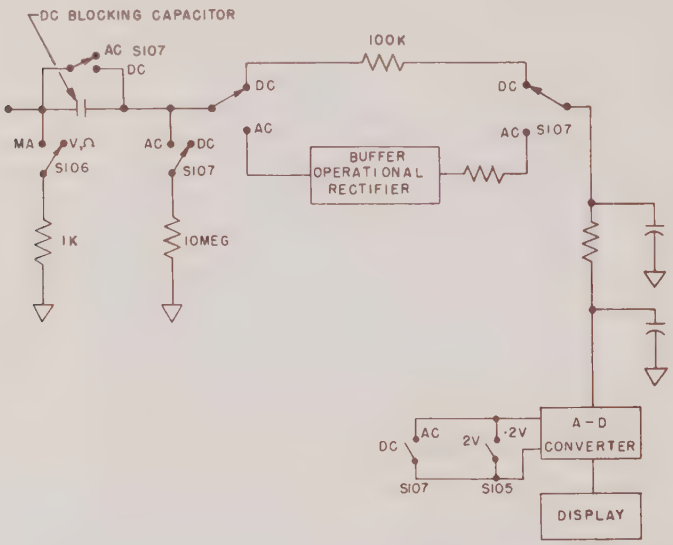


Fig. 1.8 200mV, 2V and Current Ranges

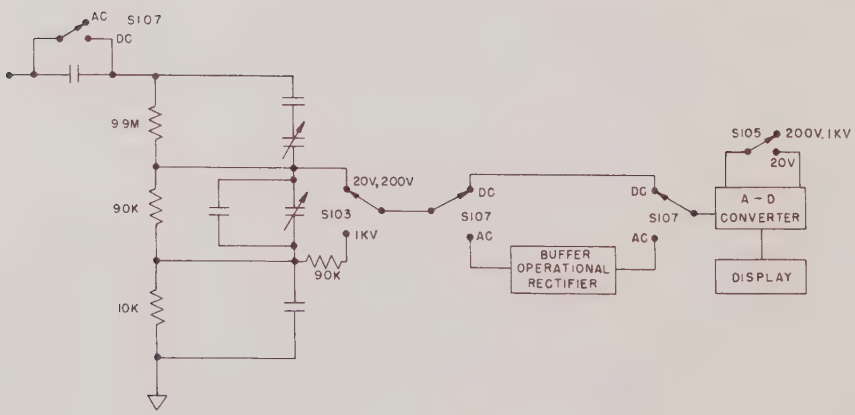


Fig. 1.9 20V, 200V and 1kV Ranges

AC BUFFER AND OPERATIONAL RECTIFIER (AC CONVERTER)

The measurement of alternating voltages is accomplished by a mean sensing, rms calibrated, operational rectifier shown in a simplified form in Figure 1.10.

The diodes at the input protect the high input impedance FET buffer stage during overload. Following the buffer circuit is the input network of the operational rectifier which sets the gain for the 200mV and 2V basic ranges.

The half wave rectified signal at point A is filtered by a three pole low pass filter and is scaled by the feedback components so that the DMM displays the rms reading, assuming a sine-wave input.

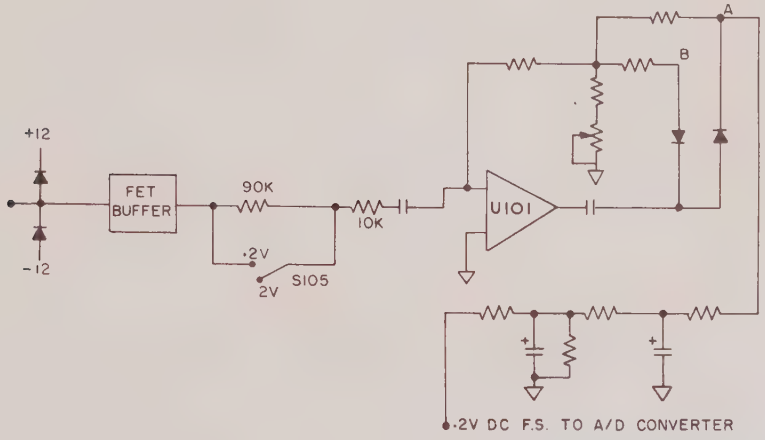


Fig. 1.10 AC Converter Circuit

RESISTANCE MEASUREMENT

The ohms circuit is shown in Figure 1.11. Fuse F102, diodes CR116 and CR115, and resistor R120 form a protection network for the current reference source.

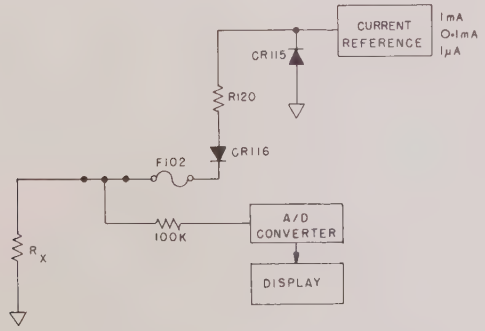


Fig. 1.11 Ohms Measurement Circuit

POWER SUPPLY

The battery charger and battery supply are shown in Figure 1.12. The fuse provides a current limiting resistance.

A dc-dc converter is used to generate the -5V, +12V and -12V power rails.

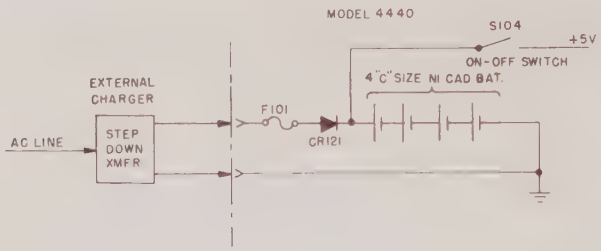


Fig. 1.12 AC Line/Battery Operation

CALIBRATION

All calibration adjustments can be performed without uncasing the instrument.

The A.C. gain potentiometer (R146) is located in the rear L.H. corner of the DMM, adjustment being possible with a narrow bladed insulated screwdriver or trimming tool. All other adjustments are accessible when the front dial plate is removed. This may be effected by inserting a blunt pointed implement into the zero set control access hole and carefully plying up the plastic front plate which will snap out.

The following calibration checks should be carried out after any repairs or whenever the instrument appears to be operating incorrectly.

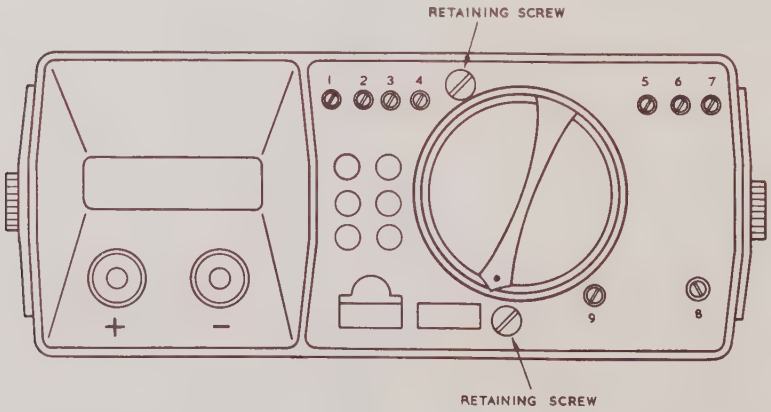


Fig. 1.13 Calibration Adjustments

(a) Select Battery TEST position on mode selection switch, reading should be at least 4.6V. If low or blank, recharge the batteries before proceeding with the following procedure.

(b) Select the 200mV DC range. Short together the input leads. Reading should be zero. If incorrect, correct by adjustment of R229 (adjustment No. 1 on front panel).

(c) Apply +190.0mV DC, adjust R257 (adjustment No. 2 on front panel) for correct display.

(d) Reverse input leads, polarity should appear -ve. If necessary, correct display by adjustment of R247 (adjustment No. 3 on front panel).

(e) Replace input leads into correct sockets, select 2V DC range on mode switch. Apply 1.900V to input. If necessary, correct display by adjustment of R233 (adjustment No. 7 on front panel).

(f) The following procedure requires the use of known value resistances preferably sub-standard quality.

(g) Select the 2M resistance range, apply a 1.900M or similar valued resistance and correct reading by adjustment of R241 (adjustment No. 4 on front panel) if necessary.

Now select the 200K range and change the resistance to 190.0K or similar, if necessary readjust R241. Now change range back to 2M range using the same resistance. Split any deviation between ranges by adjustment of R241.

(h) Select the 20K range, apply a standard resistor of 19.00K or similar. If necessary, correct the display by adjustment of R259 (adjustment No. 5 on front panel).

(j) Select the 2K range, apply a standard resistor of 1.900K or similar. If necessary, correct the display by adjustment of R258 (adjustment No. 6 on front panel).

(k) Select 200mV AC on the mode selection switch, depress the AC push button. Apply 190.0mV (50Hz - 1kHz sine-wave). If necessary, correct reading by adjustment of R146 (adjustment on rear of case).

(l) Select 1000V AC. Apply 1000V AC at 2kHz. If necessary, correct reading by adjustment of C103 (adjustment No. 9 on front panel) to 1000 ± 2 digits.

(m) Select 200V AC. Apply 190.0V AC @ 8kHz. If neccessary, correct reading by adjustment of C106 (adjustment No. 8 on front panel) to 190.0V ± 2 digits.

(n) Repeat steps (l) and (m) as necessary.

SECTION 2 Servicing

COMPONENT PARTS LIST

ABBREVIATIONS

Circuit References

B	Battery
C	Capacitor (μF)
CSR	Thyristor
CR	Diode
F	Fuse
U	Integrated Circuit
L	Inductor
LP	Lamp (including Neon)
LK	Link
M	Meter
MSP	Mains Selector Panel
PL	Plug
R	Resistor (Ω)
RL	Relay
S	Switch
SK	Socket
T	Transformer
TP	Terminal Post (or Test Point)
Q	Transistor
V	Valve
A	Other Components

Also Used:-

Z	Resistor Module

Component Composition

FIXED RESISTORS

Carbon Composition	CACP
Carbon Film	CAFM
Cracked Carbon	CKCA
Metal Film	MEFM
Metal Oxide	MEOX
Power Wirewound	POWW
Precision Wirewound	PRWW
Temperature Sensitive	TEMP
Thick Film	TKFM
Thin Film	TNFM
Voltage Sensitive	VOLT

Component Composition (Cont'd)

VARIABLE RESISTORS

Wirewound Preset Single Turn	WWPS
Wirewound Preset Multiturn	WWPM
Wirewound Front Panel Single Turn	WWFS
Wirewound Front Panel Multiturn	WWFM
Carbon Preset Single Turn	CAPS
Carbon Preset Multiturn	CAPM
Carbon Front Panel Single Turn	CAFS
Carbon Front Panel Multiturn	CAFM
Cermet Preset Single Turn	CMPS
Cermet Preset Multiturn	CMPM
Cermet Front Panel Single Turn	CMFS
Cermet Front Panel Multiturn	CMFM

CAPACITORS

Air	AIR
Aluminium Electrolytic	ALME
Aluminium Solid	ALMS
Polycarbonate	CARB
Ceramic	CERM
Polyester Foil	ESTF
Polyester Metallised	ESTM
Glass	GLAS
Mica	MICA
Metallised Lacquer	MLAC
Paper Foil	PAPF
Paper Metallised	PAPM
PTFE	PTFE
Polystyrene	STYR
Tantalum Dry	TAND
Tantalum Foil	TANF
Tantalum Wet	TANW

DISMANTLING PROCEDURE

Fuse access only

(1) Remove the two thumb screws (item 3).
(2) Screw one of the thumb screws into the tapped recessed stud and then grasping the DMM in one hand, gently ease out the battery pack (item 5) using the inserted thumb screw as a grip.

Battery and spare fuse access

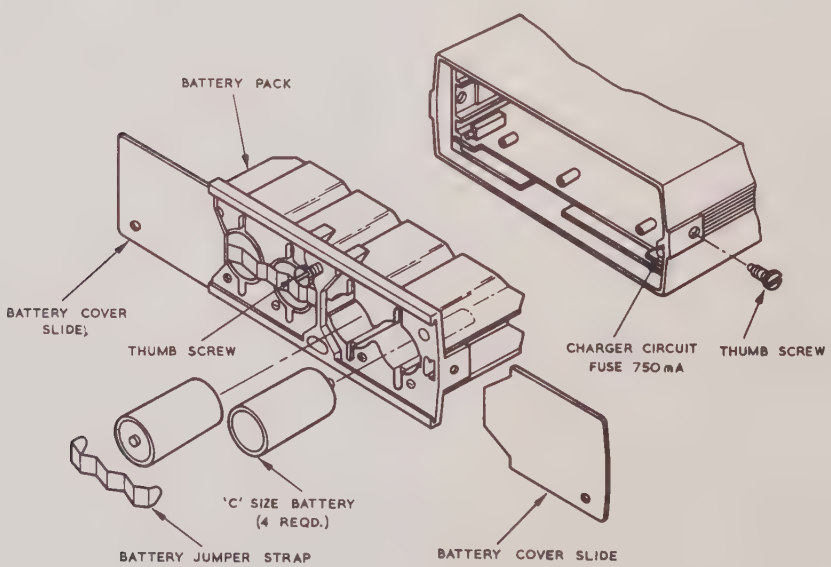
(3) Slide out the battery covers (items 6 and 7).
(4) Spring out the battery shorting strips (item 9).
(5) Slide out the battery cells.

Reverse the above sequence for reassembly.

P.C.B. removal

(1) Remove the battery pack as detailed above.
(2) Gently snap out the front dial plate (item 2) by inserting a blunt pointed implement into the zero set control hole (refer to insert) and gently plying up until the plate snaps out.
(3) Note the position of the range selection knob (item 22) index mark.
(4) Remove screws (item 13) and gently pull out the P.C.B. package from the DMM case.

Reverse the above sequence for reassembly taking care to reposition knob (item 22) as noted above and ensuring that the whole assembly is not pushed forward allowing the detent springs and rollers (items 23 and 24) to spring out of position.



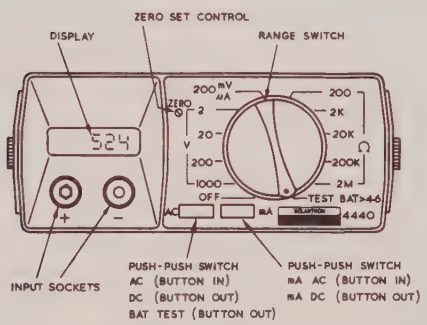
COMPONENT PARTS LIST

For

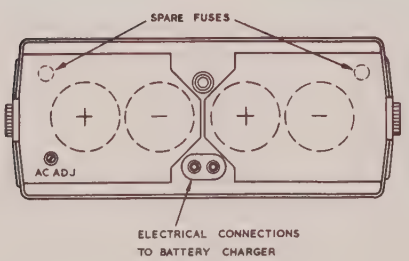
MODEL 4440 MULTIMETER

(General Assembly)

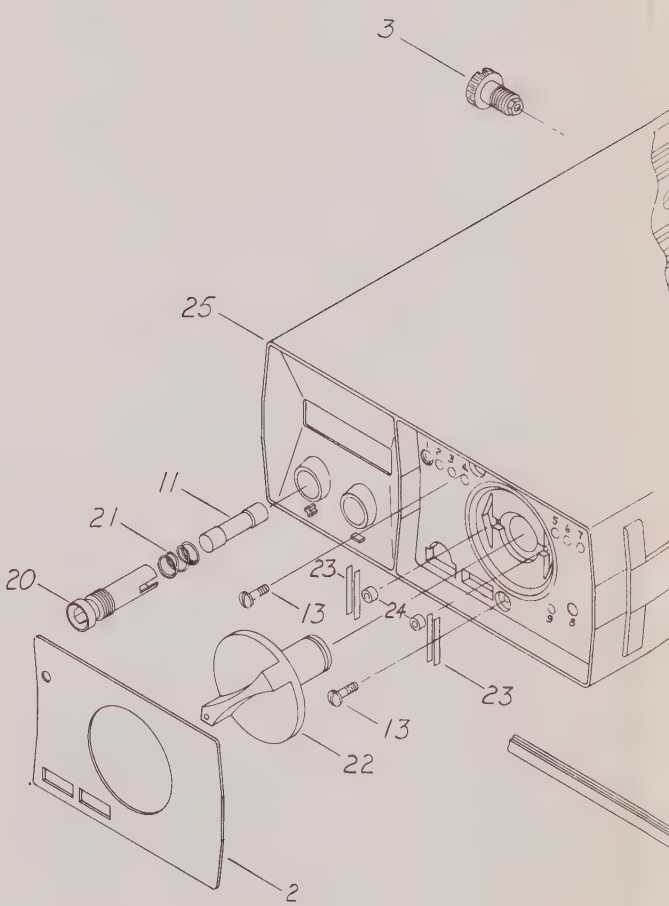
Item No.	General Description	Solartron Part No.
2	Dial, Printed	F10660035
3	Screw, Thumb	409982150
4	Handle	429700301
5	Case Assy, Battery	460200560
6	Cover, Battery	F10660040
7	Cover, Battery	F10660045
9	Contact, Battery Shorting	423010240
10	Battery, C size, 2 AH	310010100
11	Fuse, 0.031A, 8AG	360190090
12	Fuse, 0.750A, 8AG	360190100
17	Shaft, Range Switch	379901390
18	Shield, Cover	460200490
19	Shield, AC Cover, Outside	460200460
20	Socket, Fuse	360208080
21	Spring	419600401
22	Knob	400001790
23	Spring, Detent	423010220
24	Roller, Detent	470111100
25	Case, Painted	460200510
	Lead Assy.	L10660050
	Battery Charger, 210-260V 50-400Hz	L10660006



FRONT VIEW



REAR VIEW



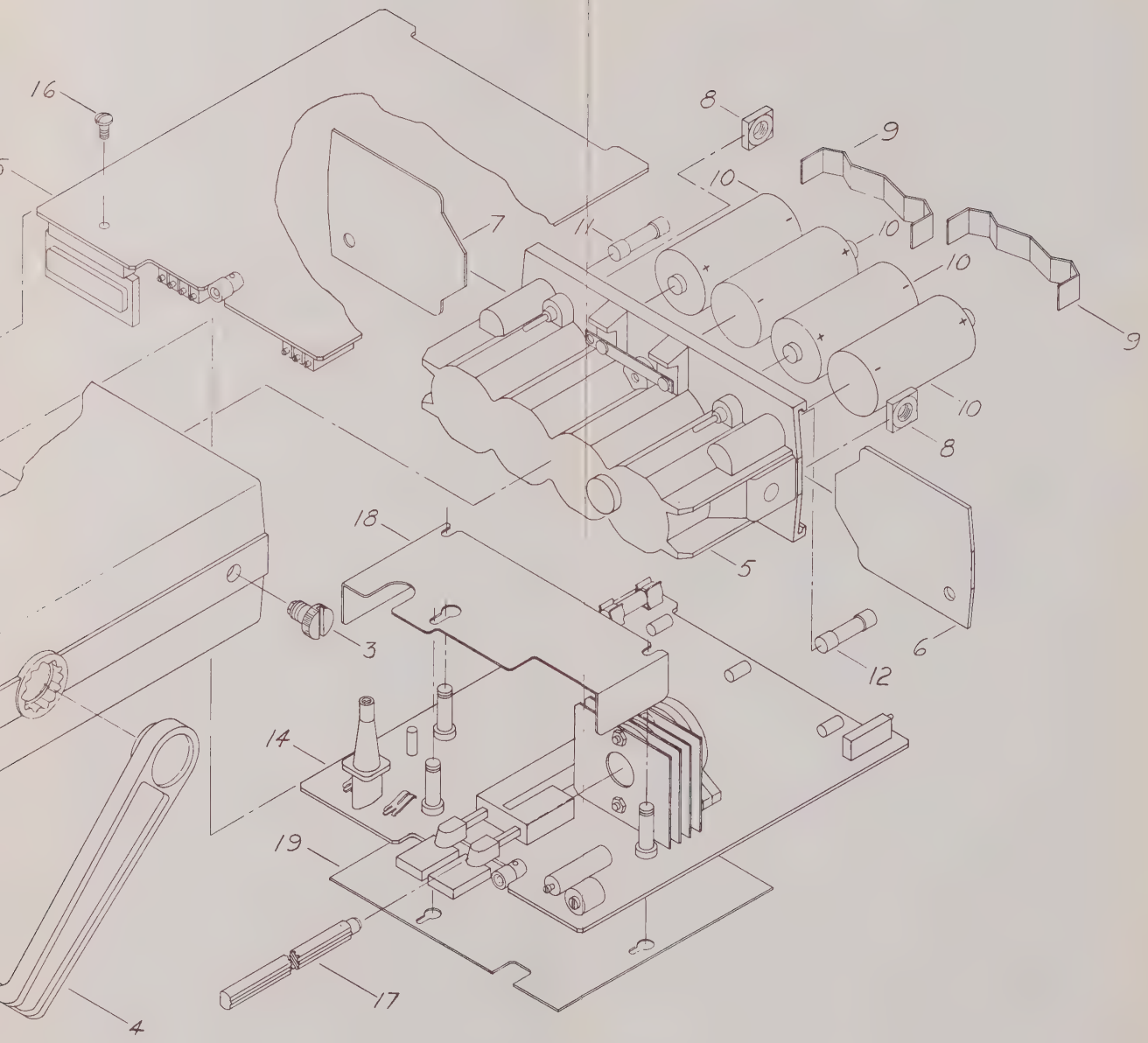


Fig. 2.1 Assembly

COMPONENT PARTS LIST

For

PCB AD 10669002

(Fig. 2.2)

Cct Ref.	General Description				Solartron Part No.
C101	CERM	.02	1kV	20%	208450120
C102	MICA	20p	500V	5%	250311800
C103	CERM	.8-26p	750V		290020470
C104	MICA	500p	500V	2%	250125000
C105	ESTM	.22	250V	20%	208200143
C106	CERM	10-60p	250V		290020460
C107	ESTM	5000p	100V	2%	208200142
C109	CERM	.01	100V	20%	208450126
C110	CERM	.01	100V	20%	208450126
C111	MICA	20p	500V	5%	250312200
C112	TAND	15	10V	20%	208700101
C113	TAND	1.0	50V	20%	266261000
C114	CERM	.0047	125V	-10% +50%	208450125
C118	TAND	15	10V	20%	208700101
C119	MICA	3p	300V	±1%	208500068
C120	MICA	3p	300V	±1%	208500068
C121	CERM	.01	100V	20%	208450126
C123	TAND	15	10V	20%	208700101
C124	TAND	2.2	15V	20%	208700102
C125	TAND	2.2	15V	20%	208700102
C126	CERM	750p	1kV	10%	208450121
C127	CERM	150p	1kV	10%	208450066
C128	TAND	15	10V	20%	208700101
C130	ALME	1600	10V	+50% -10%	260691600
C131	CERM	.01	100V	20%	208450126
C132	TAND	15	10V	20%	208700101
C133	CERM	.01	100V	20%	208450126
C134	CERM	330p	1kV	10%	208450060
L101	Choke	22μH		10%	305020570
F101	Fuse 0.75A 8AG				360190100
	Button, push				379901380
S106	Switch, Push Button				379605701
S107	Switch, Push Button				379605701
	Switch Assy, Range				L10660022
T101	Transformer				309604201
J101	Connector Molex				352510030
	Support, L.E.D. Display				300584730

Cct Ref.	General Description				Solartron Part No.
R103	MEFM	1k	¼	0.1%	160400493
R105, R106, R111, R112	Matched Set				169604201
R107	CACP	1.5k	¼	10%	172031500
R108	CACP	18	¼	10%	172011800
R109	CACP	47	¼	10%	172014700
R113	MEFM	90.9k	1/10	1%	160400507
R114	MEFM	100k	¼	1%	160400508
R115	CACP	10M	¼	5%	160100058
R116	CACP	1.5k	¼	10%	172031500
R117	CACP	1.5k	¼	10%	172031500
R118	CACP	22k	¼	10%	172042200
R119	CACP	62	¼	10%	172016200
R120	CACP	390	¼	10%	172023900
R122	MEFM	100k	½	1%	160400509
R124	CACP	47k	¼	10%	172044700
R125	CACP	22k	¼	10%	172042200
R126	CACP	33k	¼	10%	172043300
R127, R128	Matched Set				169604101
R131	MEFM	10k	1/10	1%	160400498
R132	MEFM	3.01k	1/10	1%	160400496
R133	MEFM	3.01k	1/10	1%	160400496
R134	MEFM	30.1k	1/10	1%	160400502
R135	MEFM	30.1k	1/10	1%	160400502
R136	MEFM	75k	1/10	1%	160400506
R137	MEFM	30.1k	1/10	1%	160400502
R138	CACP	100k	¼	10%	172051000
R139	CACP	100k	¼	10%	172051000
R140	CACP	15M	¼	5%	172371500
R141	CACP	15M	¼	5%	172371500
R142	CACP	18	¼	10%	172011800
R145	MEFM	464	1/10	1%	160400492
R147	CACP	5.6k	¼	5%	172035600
R146	WWPM	50		10%	121215000
Q101	Transistor 2N5354				300554930
Q102	Transistor 2N5354				300554930
Q103	Transistor 2N2712				300553920
Q104	Transistor 2N2712				300553920
Q105	Transistor E102				300553800
Q106	Transistor 2N4126				300554150
Q107	Transistor 2N5354				300554930
U101	I.C. LM301A				510000620
CR105 to CR108	Diode SD3				300522160
CR111	Diode SD3				300522160
CR113	Zener ZY12				300525121
CR114	Zener ZY12				300525121
CR115	Diode FD333				300525110
CR116	Diode IN4004				300522070
CR121	Diode IN4004				300522070
CR122	Diode FD333				300525110
CR123	Diode FD333				300525110
CR124	Diode SD3				300522160
CR125	Diode SD3				300522160

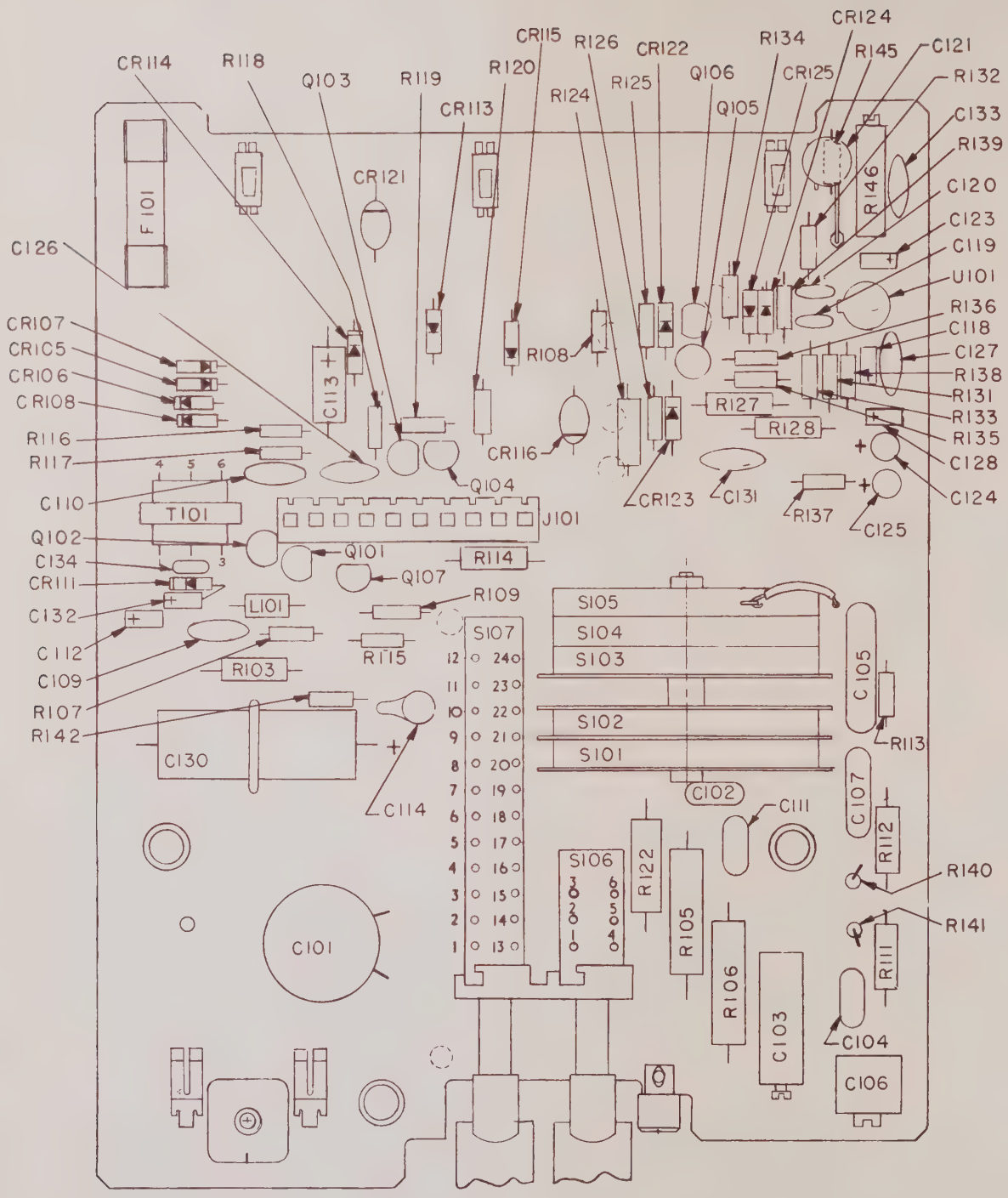
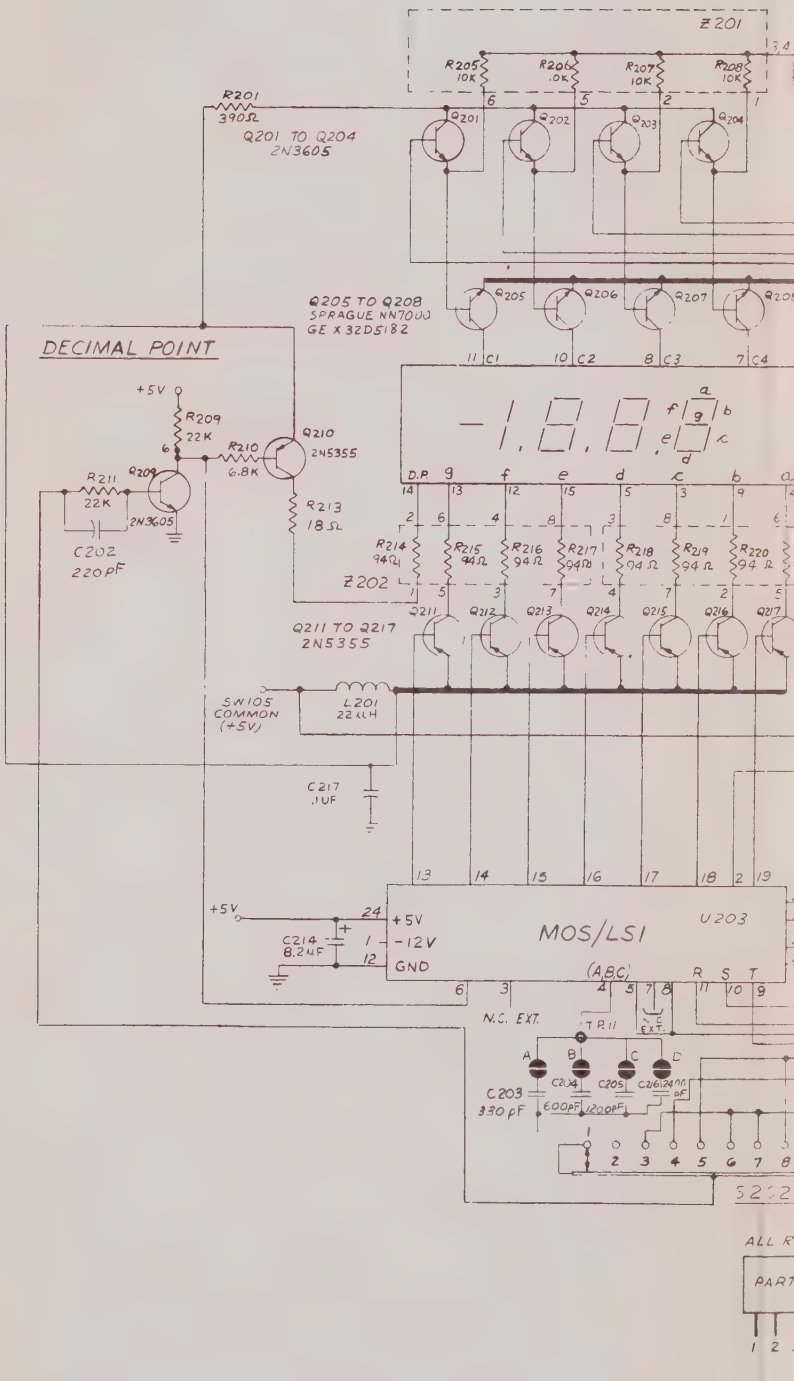


Fig. 2.2 Lower Board Assembly


Z201
R205 10K
R206 10K
R207 10K
R208 10K
R201 390Ω
Q201 TO Q204 2N3605
Q201
Q202
Q203
Q204
Q205 TO Q208 SPRAGUE NN70UJ GE X32D5182
Q205
Q206
Q207
Q208
DECIMAL POINT
+5V
R209 22K
R210 6.8K
Q210 2N5355
Q209
R211 22K
2N3605
C202 220PF
R213 18Ω
D.P. g f e d c b a
R214 94Ω
R215 94Ω
R216 94Ω
R217 94Ω
R218 94Ω
R219 94Ω
R220 94Ω
Z202
Q211
Q212
Q213
Q214
Q215
Q216
Q217
Q211 TO Q217 2N5355
SW105 COMMON (+5V)
L201 22 μH
C217 .1UF
+5V
C214 8.2μF
+5V
-12V
GND
MOS/LSI
U203
(A,B,C)
R S T
N.C. EXT.
TRII
EXT.
A
B
C
D
C203 330 pF
C204 600PF
C205 1200PF
C216 2400 PF
1 2 3 4 5 6 7 8

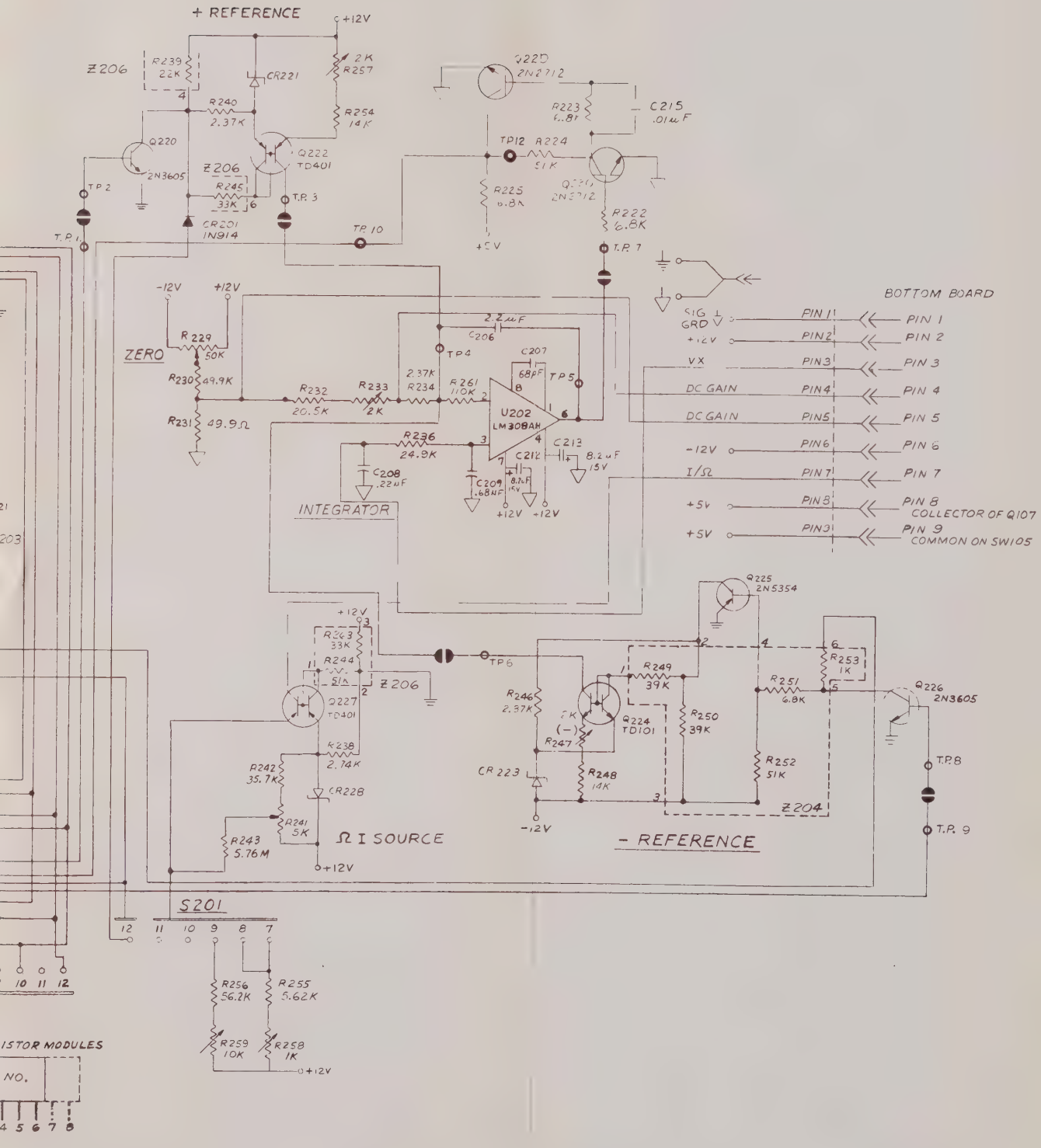
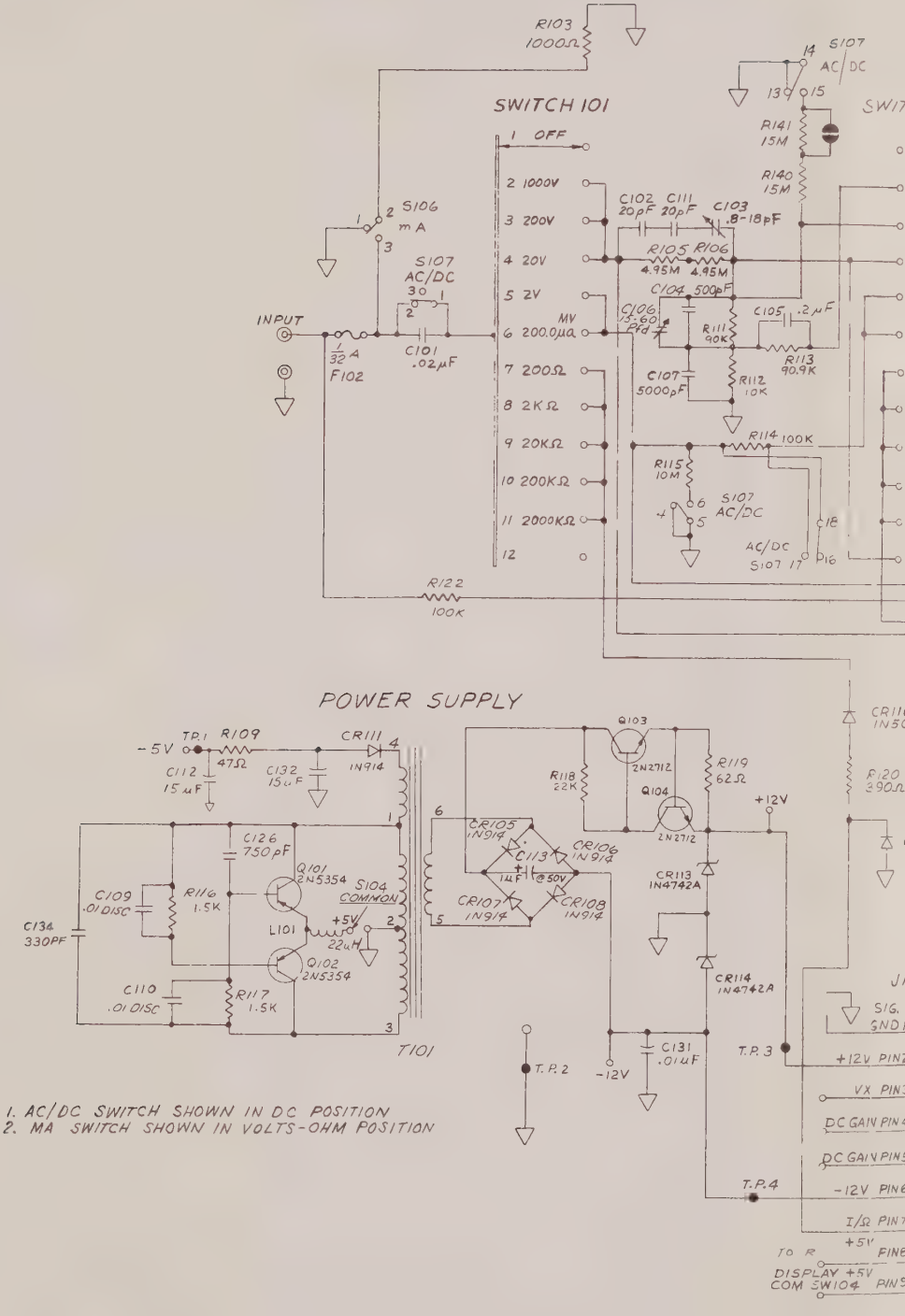


Fig. 2.5 Upper Board Circuit Diagram



1. AC/DC SWITCH SHOWN IN DC POSITION
2. MA SWITCH SHOWN IN VOLTS-OHM POSITION

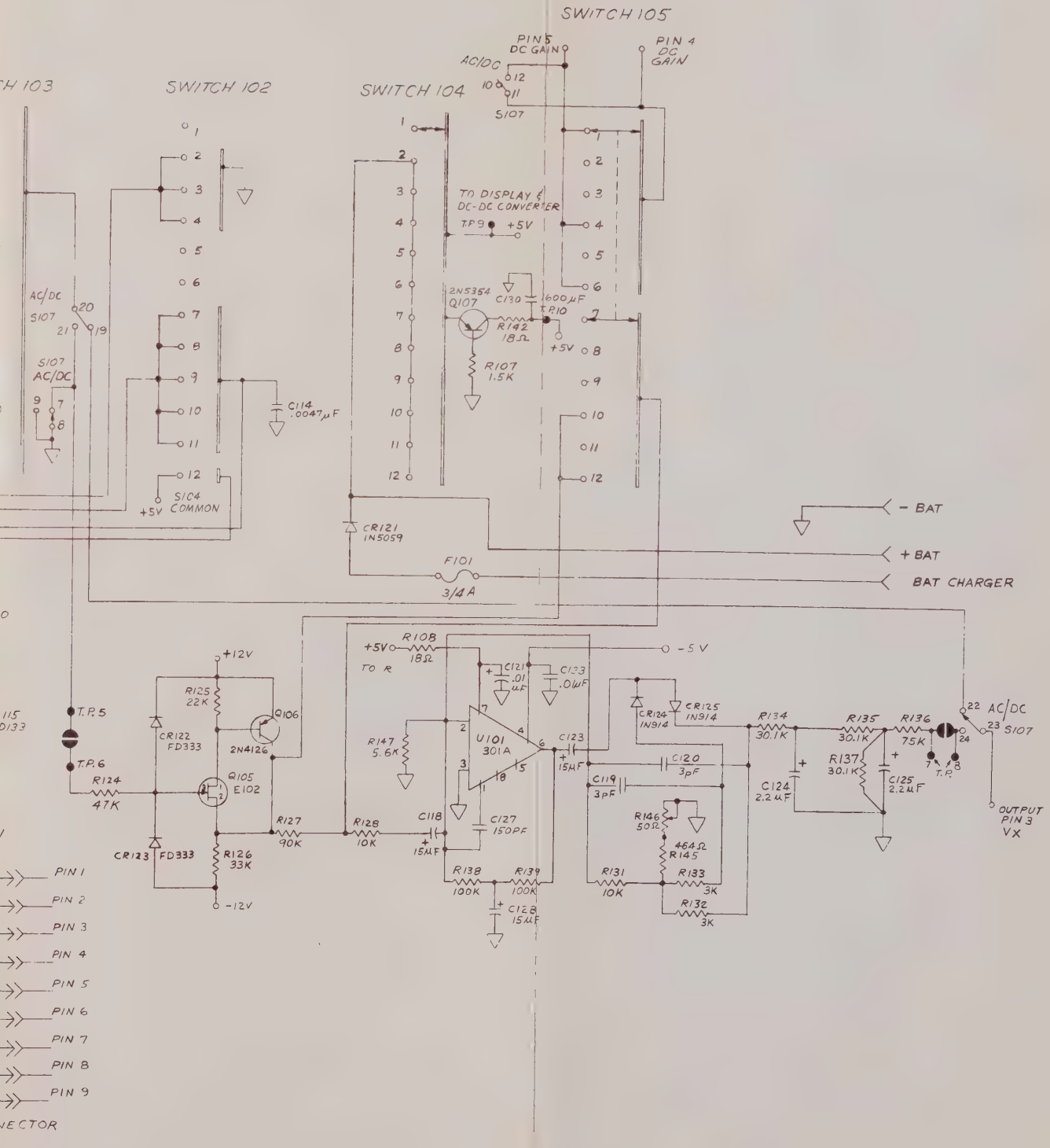


Fig. 2.3 Lower Board Circuit Diagram

COMPONENT PARTS LIST

For

PCB AD10669001

(Fig. 2.4)

Cct Ref.	General Description				Solartron Part No.
C202	CERM	220p	1kV	10%	208450044
C203	CERM	330p	1kV	10%	208450060
C204	CERM	600p	500V	10%	208450122
C205	CERM	1200p	500V	10%	208450123
C206	ESTM	2.2	250V	10%	225762200
C207	CERM	68p	1kV	10%	208450058
C208	ESTM	.22	250V	20%	208200143
C209	ESTM	.68	250V	10%	225756800
C212 to C214	TAND	8.2	15V	20%	265668200
C215	CERM	.01	100V	10%	208450126
C216	CERM	2400p	500V	10%	208450124
C217	CERM	0.1	10V	+80% -20%	208450134
Z201	Res. Module				169604401
Z202	Res. Module				169604701
Z203	Res. Module				169604701
Z204	Res. Module - REF				169604301
Z206	Res. Module + REF, Ω				169604501
SK201	SKT Receptacle L.S.I.				355900820
L201	Choke	22μH		10%	305020570
A201	Display L.E.D. 3½				309400301
	Switch Assy, Range				L10660018
R201	CACP	390	¼	10%	172023900
R209	CACP	22k	¼	10%	172042200
R210	CACP	6.8k	¼	10%	172036800
R211	CACP	22k	¼	10%	172042200
R213	CACP	18	¼	10%	172011800
R222	CACP	6.8k	⅛	10%	172036800
R223	CACP	6.8k	¼	10%	172036800
R224	CACP	51k	¼	10%	172045100

Cct Ref.	General Description				Solartron Part No.
R225	CACP	6.8k	¼	10%	172036800
R230	MEFM	49.9k	1/10	1%	160400504
R231	MEFM	49.9	¼	5%	160400491
R232	MEFM	20.5k	¼	1%	160400500
R234	MEFM	2.37k	¼	1%	160400494
R236	MEFM	24.9k	¼	1%	160400501
R238	MEFM	2.74k	¼	1%	160400495
R240	MEFM	2.37k	¼	1%	160400494
R242	MEFM	35.7k	¼	1%	160400503
R243	MEFM	5.76M	¼	1%	160400511
R246	MEFM	2.37k	¼	1%	160400494
R248	MEFM	14k	¼	1%	160400499
R254	MEFM	14k	¼	1%	160400499
R255	MEFM	5.62k	¼	1%	160400497
R256	MEFM	56.2k	¼	1%	160400505
R261	MEFM	110k	¼	1%	160400510
R229	WWPM	50k		10%	121245000
R233	WWPM	2k		10%	121232000
R241	WWPM	5k		10%	121235000
R247	WWPM	2k		10%	121232000
R257	WWPM	2k		10%	121232000
R258	WWPM	1k		10%	121231000
R259	WWPM	10k		10%	121241000
CR201	Diode SD3				300522160
CR221	Zener IN821				300525250
CR223	Zener IN821				300525250
CR228	Zener IN821				300525250
Q201 to Q204	Transistor 2N3605				300554700
Q205 to Q208	Transistor NN7000				300554910
Q209	Transistor 2N3605				300554700
Q210 to Q217	Transistor 2N5355				300554920
Q220	Transistor 2N3605				300554700
Q222	Transistor TD401A				300554600
Q224	Transistor TD101A				300554590
Q225	Transistor 2N5354				300554930
Q226	Transistor 2N3605				300554700
Q227	Transistor TD401A				300554600
Q229	Transistor 2N2712				300554800
Q230	Transistor 2N2712				300554800
U202	I.C. LM308				519600401
U203	I.C. M.O.S. L.S.I.				510001330

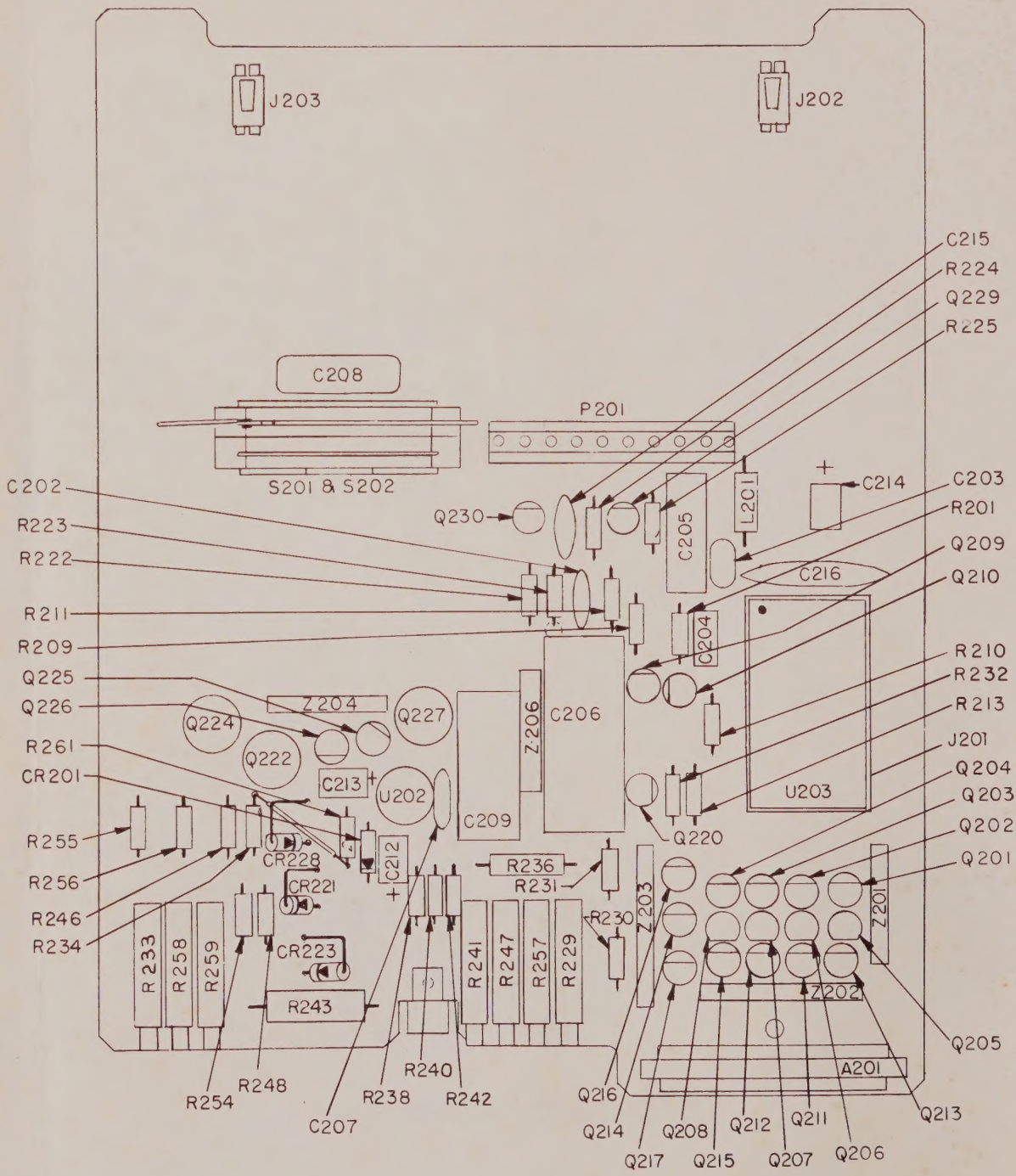


Fig. 2.4 Upper Board Assembly